Using LCA and Network Theory as a basis for eco-efficiency improvements in Norwegian plastic packaging recycling

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Introduction

Life Cycle Assessment (LCA) is to a wide extent applied to evaluate the environmental performance of recycling. However, LCA is not sufficient as stand-alone tool for decision-making regarding recycling since decisive factors such as the economical cost and incomes, are not included. To combine both environmental- and economic information the *life cycle eco-efficiency assessment* (LCEEA) may be a more suitable tool (Eik 2002). Here indicators such as recycling rate, CO_2-emissions and net cost are applied in order to quantify environmental- and economic performance of various types of recycling and waste management systems.

LCA and LCEEA are appropriate tools to *examine* the environmental- and/or economic performance of a given recycling system/chain and to *identify* areas of improvement such as to costly sorting or to CO2-intensive transport in the chain. However, these tools are not able to give us a *deeper understanding* about the identified areas of improvement in the recycling system/chain. To elucidate this we propose to combine LCEEA and the *resource interface perspective* within industrial network theory (Gadde and Håkansson et al 2002,Wedin 2001). We are suggesting that further information on identified areas of improvement can be found by studying resource interfaces between a defined focal resource and its network of inter-linked resources.

In this paper we will have a closer look on the Norwegian deposit systems for recycling of one-way plastic (PET) bottles, where we have interviewed major actors. Use of LCEEA have identified the collection unit, the reverse vending machine (RVM), to be the most important area of improvement to increase the recycling rate and reduce the costs of sorting, transporting and recycling (Eik et al. 2002). The RVM is therefore chosen to be the focal resource to be further investigated.

A framework to analyse resource interfaces (1 s)

Within the industrial network theory as developed by Håkansson and colleagues, the basic idea is that is not sufficient to study actors, activities and resources along one supply, distribution or recycling chain (Gadde and Håkansson et al 2002). Actors, activities and resources belong to more than one recycling chain, and their participation and interdependencies with actors, activities and resources in other production, distribution and recycling chains will influence their performance in the defined recycling chain/system.

Networks have until recently mainly been studied from an activity (and actor) perspective. However, according to Gadde et al (2002) it can be argued that resources are the foundation of activities and are thus the most interesting factor to study. Resources are regarded as "facilitators of operations", in supply and distribution networks, included reverse logistics/recycling systems. In classic microeconomic analysis the basic assumption is that the value of a specific resource is a given – i.e. the value is independent of how this resource is combined with other resources. Resources are regarded as 'homogeneous', and the key issue is to allocate these given resources to given means (Pasinetti 1981). The opposite view, and the view we support, is based on the assumption that resources are heterogeneous – i.e. the value of a resource can and will vary, depending on how it is used and particularly on the ways in which it is combined with other resource elements (Alchian & Demsetz 1972). We therefore argue that all resources in a defined recycling chain and its appurtenant network can potentially be further developed and thus lead to increased overall eco-efficiency of the chain. Development of resources can potentially occur through current and new resource interfaces between various resource units in the network.

Resources can be divided into four types: "Facilities" and "products" which represent the technical/physical dimension and "business units" and "business relationship" which cover the organisational aspects (Håkansson & Snehota 1995). The framework for analysing the present use, as well as potentials for developing the use of resources in network is illustrated in figure 1. This resource network triad consists of three business units, three business relations, three production facilities and three products. In a network triad there are hence eleven possible resource interfaces between the focal resource (here chosen to be facility) and the rest of the resource elements. We have illustrated five of these resource interfaces.

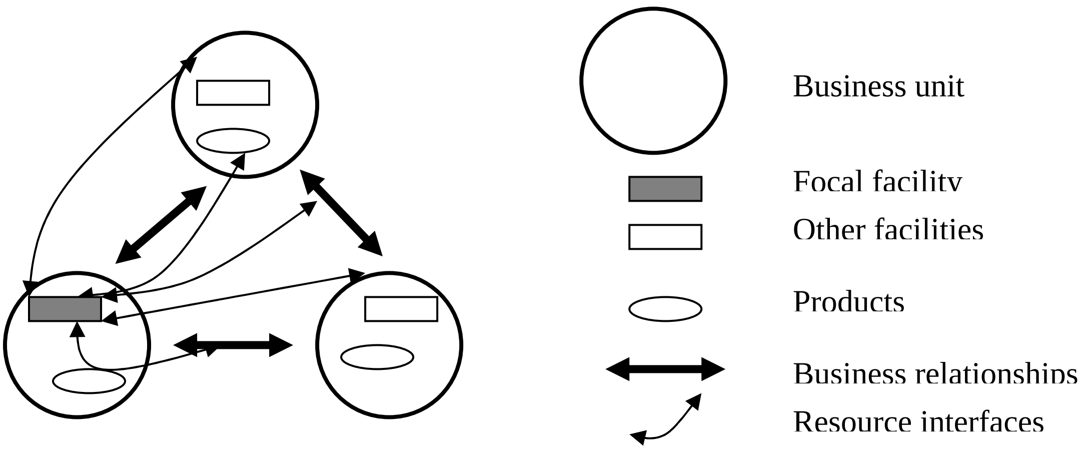

Figure 1: A framework to analyse resources in a network triad

As mentioned above we hope to acquire more information about identified areas of improvement in the deposit system by identifying and understanding the major resource interfaces between the most important resource in the system and other resources. We will do this by studying resource interfaces between the focal resource RVM and its network of inter-linked resources. Our hypothesis is that the major resource interfaces will have the strongest influence on the efficiency of the RVM and thus the overall eco-efficiency of the system. These are the resource interfaces to work with to improve the eco-efficiency of the system.

Resource interfaces which influence the eco-efficiency

We will first very shortly describe the focal resources, the facility RVM, and mention it's identified interfaces with similar resources (other facilities) and with other resources (products, business units, business relationships), see (Jahre and Eik 2002) for a more comprehensive description. Thereafter we will highlight the RVM's major facility-, product-business unit- and business relationship interface. These are the interfaces that we have found to be most decisive for the RVMs contribution to the environmental and economic efficiency in the deposit recycling system.

<u>The focal resource</u>
This particular facility is a Tomra 600 model that was launched in 1997. It handles both refillable and non-refillable containers including glass, PET and cans – all containers included in the return for deposit system in Norway as long as they fulfil a set of predetermined specifications.

<u>RVMs interfaces with similar resources (*facilities*) in the recycling chain</u>

- RVM – installation and backroom solution
- RVM – collection vehicle and materials handling equipment off site
- RVM – on-line support network and data administration system

<u>RVMs interfaces with other resources in the recycling chain</u>

- RVM – The *products* non-refillable- (included PET), refillable- and non-deposit containers
- RVM – The *business units* Tomra Systems ASA, the Rema store, and the system administrator Resirk
- RVM – The *business relationships* between Rema store/Tomra, Rema store/Resirk, Resirk/producers and importers of non-refillable containers.

<u>Most important resource interfaces with respect to efficiency of one-way PET bottles</u>

The RVM's major resource interface with *facilities* is the *on-line support network and data administration system*. These are features that ordinary collections systems do not offer. This product interface makes it possible to include more PET types in the system for a low cost, since no marketing towards end-consumers on which products to sort out is required.

The main *product* resource interface is non-refillables and in particular PET because its volume is increasing, it has marked the development of the RVM to a great extent and because the interface between the RVM, the backroom solution and the collection is challenging with the present logistics. The PET bottle is sorted automatically into a large bag after being flattened. If the machine is not able to "read" the bottle, or if it ends up in a bag for cans, the bottle may not be recycled later on. By further improving the advanced detection system, increasing the compaction grade of the bottles and improving the capacity of the big bag, the costs can be reduced and the recycling rate be improved.

The most important *business unit* interface is *Resirk* because they administrate the cash flow and material flow in the deposit system. Owned by retailer, industry and its within their interests to increase the recycling rates and reduce the costs in the system.

The *business relationship* interface with most influence on the RVM is the one between Tomra and the Rema store. The store has a service agreement with Tomra. The RVM is continuously under development in order to improve the efficiency of the handling in the store and in the later transportation, sorting and recycling process.
Below the most important resource interfaces are shown, similarly as in figure 1.

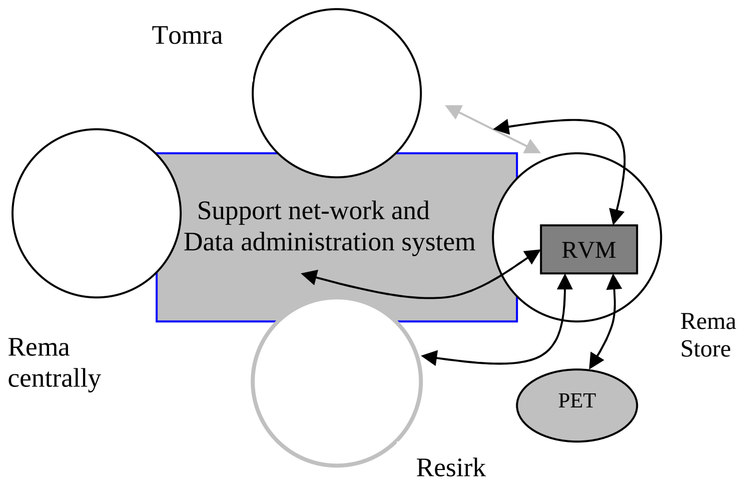

Figure 2: The RVM's resource interfaces

Summary

We have presented how use of LCA to evaluate recycling can be extended to include the resource perspective within industrial network theory. By doing this we are able not only to identify the environmental- and economic improvement areas in the recycling chain, we are also able to acquire a deeper understanding of these areas of improvement. This is carried out by identifying and studying the resource interfaces between the focal resource in the recycling chain and similar and other resources in the focal resource's network.

We have applied this new approach on the deposit system for one-way PET bottles in Norway, where the reverse vending machine (RVM) is identified as the focal resource. The RVM's major resource interfaces to focus on are the facility support network and data administration system, the product PET-bottles, the business unit Resirk, and finally the business relationship between Tomra and the Rema Store.

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